following contemporary tendencies in school and church. Professor George A. Coe's reported difficulties with the Methodists at Northwestern University and his acceptance of a chair at Union Theological Seminary are anomalous products of two conflicting movements in the educational and religious worlds —movements which may, in the course of years, lead to still more curious situations.

Andover's transfer to Cambridge and Union Theological Seminary's approaching shift to Morningside Heights reflect a yearning for university affiliations, born partly of intellectual discontent and partly of necessity. Unlike the college freshman, many theological professors and most theological students have felt the power of modern science and thought, and the weakness of dogmatics, apologetics, and Hebrew grammar as defenders of their faith. Not long ago, one of the largest seminaries in the country was peremptorily ordered by its students to modernize its curriculum; and, on every hand, the demand is being made that religious opinions be left to individuals, and the seminary teach biology, psychology, history, ethics, hygiene, and social reform. The result, at this hour, is incongruous in the extreme. While the universities are crying, "Let the seminaries come to us, that we may be spiritualized!" theological students ask for a chemical laboratory that they may be trained in modern scientific method. But the incongruity is natural. The forces of intellectual conservatism reside in the masses; they make themselves felt most acutely in the ordinary college simply because the latter is the meeting-place of culture and the average man. In the seminary, though, and particularly in those which have lived through an open controversy between dogma and liberalism, a handful of cultivated churchmen, half secluded and full of doubts, are seeking to square their beliefs with modern knowledge and their practises with the needs of modern life. Their own perplexities and their remoteness from the unschooled laity make them liberals. No wonder, then, that a training school for Protestant ministers may welcome a philosopher obnoxious to a nominally unsectarian university.—New York *Evening Post.*

DISCUSSION AND CORRESPONDENCE

MATHEMATICS FOR ENGINEERS

To the Editor of Science: I have followed the recent discussion of mathematics for engineers with much interest and with a great sense of satisfaction that at last the discussion of technical education is being published in a place where it must, perforce, be brought to the notice of our physicists; for our physicists (I mean to refer to them here in their capacity as teachers) have paid but little attention to the remarkably active discussion of technical education that has been going on for several years.

Something is wrong with technical education, that is quite evident, but I am not entirely satisfied with any diagnosis which up to this time has been given of the situation. I think that the most vital question which now confronts us in the field of technical education is how adequately to establish the *perceptive phase* of the physical sciences. In order that I may explain precisely what I mean by this expression, I must use an example:

Nothing is more completely established by experience than the necessity of employing an active agent, such as a horse or a steam engine, to drive the machinery of a mill or factory, to draw a car, or to propel a boat. The common feature of every case in which motion is thus maintained is that *a force is exerted upon a moving body and in the direction in which the body moves.* Such a force is called an *active force*, and to keep up an active force involves continuous effort, or cost. A force which acts upon a stationary body, on the other hand, may be kept up indefinitely without cost or effort; such a force is called an *inactive force.* Thus, a weight resting on a table continues to push downwards on the table, a weight suspended by a string continues to pull on the string, the mainspring of a watch continues indefinitely to exert a force upon the wheels of the watch if the watch is stopped. The idea of an inactive force is applicable also to a force which acts upon a moving body, but at right angles to the direction in which the body moves. Thus, the force with

which a driver pushes vertically downwards on a moving cart is an inactive force, the vertical pull of the earth on a railway train which moves along a level track is an inactive force.

An active force is said to do work and the amount of work done in a given time is equal to the product of the force and the distance that the body has moved in the direction of the force.

This is taken almost verbatim from the text-book on "Elementary Mechanics" which was recently used with a freshman class in one of our best technical schools (only 126 pages of the text were covered during the excessively short time allotted to this subject) *and 43 per cent. of the class at the time of the final examination (counting the 20 per cent. who were so hopelessly deficient that they were not allowed even to try the final examination) were so deficient in physical imagination, or power of perception, or whatever one may prefer to call it, that they blindly calculated that the man was doing nearly twice as much work as the mule in the following problem:*

A cart moves northwards with a velocity of 6 feet per second, a mule pulls northwards on the cart with a force of 90 pounds, and a man exerts on the cart a downward force of 150 pounds. At what rate is work done by the mule and at what rate is work done by the man?

To have named the part of his body the man used in pushing down on the cart might have stimulated the perceptive powers of the dullest members of the class; indeed the instruction during the term did resolve itself many times into things as unreservedly elemental as this; but have we not a right to expect our students, at least at examination time when their greatest effort is put forth, to be able to handle abstract (!) problems like this of the hard-working cart driver and his pampered mule?

SCIENTIFIC PERCEPTION

I was greatly pleased to see Professor Swain bring up Sir William Hamilton's ideas, seventy years old. Perhaps your readers will welcome an idea from William Whewell which is also seventy years old. It is almost the only idea I was able to find years ago when I read the "Philosophy of the Inductive Sciences," but it is a creditable thing to have produced one idea; indeed, it would be a creditable thing in our time even to adopt ideas! Whewell says that ideas of perfect precision are a paramount possession (the four p's are Whewell's; he might well have omitted at least one of them as I do in the paraphrase). Nothing is so essential in the acquirement of real knowledge of physical things as the possession of precise ideas, not indeed because a perfect precision is necessary as a means for retaining knowledge, *but because nothing else so effectually opens the mind for the perception even of the simplest evidences of a subject.*

(In the final examination in elementary mechanics above referred to, the following note was appended to one of the questions:

A redundant or wrongly used word in answer to this question will be graded zero,

and a day or two after the examination a member of the faculty (*not* a professor of mathematics) quoted this note in derision, as if the only precision were numerical precision! May the shade of William Whewell protect us!)

In order to be able to define in a general way the perceptive phase of the physical sciences, let me distinguish two chief results of the scientific activity of the nineteenth century, namely, (1) an accumulated mass of fact, under which heading I would include all of the details of applied science, for indeed the most important and compelling facts that have been accumulated by the sciences are the facts which are incorporated in the settled doings of men, and (2) an established mode of thought and inquiry which may be designated, using a suggestive phrase of Bacon's, as "A new engine, or a help to the mind corresponding to tools for the hand." Here is an idea three hundred years old!

We continually force upon the extremely meager data which are obtained directly through our senses an interpretation which in its complexity and penetration would seem to be entirely incommensurate with the given data, and the possibility of this forced interpretation depends upon the use of two complexes, (*a*) a logical structure, that is to say,